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GB 2265924 A EP 0572113 A EP 0137872 A

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(54) Drilling fluid

(57) An aqueous drilling fluid comprises an aqueous medium a caesium salt and at least one of a fluid loss additive, an organic water soluble shale dispersion inhibitor and a weighting agent. Caesium salts are much more effective than potassium salts as shale inhibitors in aqueous drilling fluids.

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DRILLING FLUID

This invention relates to water-based drilling fluids which are suitable for use in shale and clay formations.

A drilling fluid is used in conjunction with the rotary system of drilling. The drilling fluid is pumped from the surface down the inside of the rotating drill string, discharged through ports in the bit and returned to the surface via the annular space between the drillstring and the hole.

The drilling fluid serves to cool and lubricate the bit and drill string, bring drill cuttings to the surface, consolidate the side of the drilled hole, prevent squeezing-in or caving of the formation, control subsurface pressures, suspend drill cuttings when the column is static and minimise damage to any potential pay zone that might be encountered.

Drilling fluids generally contain a carrier, a weighting agent and chemical additives. They are commonly divided into two categories, water based muds (WBM) and oil based muds (OBM). In the former the carrier is an aqueous medium and in the latter it is an oil. Diesel oil was used in the past as the oil, but recently low toxicity drilling oils have been developed for this purpose.

While WBM are more environmentally acceptable than OBM (since the latter still give rise to the problem of disposing of large quantities of oil contaminated drill cuttings, even if the oil is of low toxicity) they are recognised as being technically inferior in a number of important areas such as thermal stability, lubricity, and shale inhibition.

Although shale is soft and therefore relatively easy to drill through, it still causes many problems for the drilling engineer. It disperses easily into the fluid, large lumps break off and fall into the hole, pores in the shale can contain fluids trapped under pressure, and in extreme cases, the borehole wall may collapse.

Since shale makes up a high proportion of the rocks drilled in exploratory and production wells for oil and gas, particularly in important producing areas such as the North Sea, it is important that drilling times and problems be kept to a minimum when drilling through such formations.

Many WBM formulations incorporating additives have been suggested in an attempt to control reactive shales. Such additives include:

(a) salts such as potassium chloride to limit water uptake, reduce the swelling of the shale, and reduce leaching of any salt deposits encountered,

(b) chemically modified starch or cellulosic materials which are used to reduce fluid loss,

(c) water soluble polyacrylamides or other water soluble polymers which adsorb on the surface of shale to bind it with a coating of polymer, thereby reducing dispersion of the shale,

(d) lime or gypsum which, although sparingly soluble, act in a similar manner to (a), and

(e) asphaltene derived products which assist in fluid loss control by acting as blocking agents for cracks and microfractures.

To date, however, none of these formulations has been able to provide shale inhibition to the levels achieved with OBM.

This is because an OBM does not react with shale. A conventional WBM will, however, react to a greater or lesser extent with many shales causing them to swell and can give rise to problems such as stuck pipes, tight hole, overgauge hole, poor directional control, poor cementing and poor mud condition (leading to extensive dumping and diluting and therefore high mud costs).

It is an object of the present invention to develop a WBM which approaches the technical performance of an OBM without sacrificing its environmental advantages.

We have now discovered that caesium salts are much more effective than potassium salts as shale inhibitors in aqueous drilling fluids.

Accordingly the present invention provides an aqueous drilling fluid comprising.

(a) an aqueous medium

(b) a caesium salt, e.g. in amount of 0.5-50, preferably 1-40, 4-20 or 10-30 ppb (pounds per barrel) but especially 1.2-18 or 3.0-9.0 ppb; or 0.85-150, e.g. 1.43-143, preferably 2.86-114, 11.4-55.2 or 28.6-85.8 g/l, but especially 3.4-51 or 8.5-25.5 g/l.

and at least one of

(c) a fluid loss additive, e.g. in amount 0.5-15 ppb, e.g. 1-5 ppb, i.e. 1.43-42.9 g/l, preferably 2.86-14.3 g/l.

(d) An organic water soluble shale dispersion inhibitor, e.g. in amount of 0.25-20 ppb (0.72-57.2 g/l) preferably 0.5-5 ppb (1.43-14.3 g/l)

(e) and a weighting agent, e.g. in amount 5-500 ppb (14.3-1430 g/l) preferably 10-400 ppb (28.6-1144 g/l).

The present invention also provides a method for drilling through shale using an aqueous drilling fluid, which comprises drilling using an aqueous fluid comprising a caesium salt. In the method of the invention a borehole is cut with a cutter into the ground, whether on land or under water, usually with a rotating drillstring, with circulation of an aqueous drilling fluid down the hole past the cutter and back up the hole; usually the fluid passes through the drillstring past the drill and returns up the annulus between the drillstring and wall of the borehole.

The caesium salt may be present in an amount of 0.005-0.8, e.g. 0.02-0.3, but especially 0.05-0.15 g atom per litre of aqueous medium. The caesium salts may be acidic, e.g. acid sulphate or basic, e.g. carbonate or bicarbonate or acid phosphate, but are

preferably substantially neutral, e.g. halide such as chloride or bromide or sulphate or carboxylate, e.g. from an aliphatic carboxylic acid of 1-10 carbons, such as formate, acetate or propionate. Caesium chloride or caesium formate hydrate are preferred. The caesium salt may constitute at least the majority of the content of alkali metal of atomic number of at least 19 present in the fluid and may constitute substantially the whole content of said metal, e.g. at least 90%, there being e.g. only small amounts, e.g. less than 10% by weight of potassium salts or bases.

Suitable fluid loss additives include starch, carboxymethyl cellulose and other conventional additives, provided that they are compatible with the other components.

Suitable shale inhibitors include polyacrylamides (either anionic or cationic) such as partially hydrolysed polyacrylamide, e.g. of molecular weight 1-20 million, and polyamines, preferably a dimethylamine epichlorhydrin polyamine copolymer of molecular weight in the range 10,000 to 500,000.

Suitable weighing agents are gypsum, barite, haematite and galena.

Preferably the fluid also comprises

(f) a monomeric or polymeric di- or poly-hydric alcohol or an ether or ester of such a compound in amount 5 to 20% by volume of the total volume of the fluid, preferably 5 to 10% by volume.

The fluid may also contain additional conventional ingredients such as viscosifiers, e.g. xanthan gum; and pH control agents, e.g. sodium or potassium hydroxide. The pH is suitably controlled to a value in the range 7 to 13, especially 8.5-11.5.

The aqueous medium may be fresh or saline water or simulated brine.

Suitable anionic polyacrylamides are those sold under the Trade Names Alcomer 120L by Allied Colloids and Drillam EL by Lamberti.

Suitable polyamines include those sold under the Trade Name Magnafloc 297 by Allied Colloids and Nalfloc 7607 by Nalfloc Ltd.

Suitable alcohols and esters include glycols, polyglycols, glycerols, polyglycerols and esters of such compounds.

A benefit of the caesium salts over potassium salts as shale inhibitors is that smaller amounts may be used, in particular 10-100 times smaller amounts, or alternatively similar amounts can be used to give a larger effect. The caesium salts can act to minimise the dispersion/swelling of clay rich rocks (e.g. shales). The improved shale inhibition properties can lead to improved well bore stability, increased life time of the drilling fluid, faster drilling and reduced drilling time.

The caesium salts may be used especially in slimhole drilling in which the hole is 7 inches diameter, over part or all of the total well depth. The advantage over conventional hole geometries is that most of the associated equipment can be scaled-down in size and weight. This makes slimhole drilling particularly suitable for remote locations where equipment and chemical transportation costs are likely to be high. Because of the smaller dimensions of slimhole drillpipe it is weaker than conventional drillpipe and cannot be loaded to the same extent to produce high drilling rates. To compensate for this the pipe is rotated at higher rotational speeds. Thus slimhole drilling is distinguished from conventional drilling by high pipe rotation speeds of the order of 500-1200 rpm and a narrow annulus which can be as small as 1/8th inch between the drillpipe and the wall. The narrow annulus can give rise to high pressure losses in the circulating mud system. The caesium salt shale inhibitors can provide a drilling fluid formulation which has a low viscosity to reduce pressure losses. The fluid is suitable for drilling reactive shales and is particularly relevant to coring applications where small amounts of drill cuttings are generated and the cuttings are of small size.

The invention is illustrated with reference to the following Examples.

<u>Examples</u>

In each experiment to compare the shale inhibitive properties of a fluid containing an alkali metal chloride salt the procedure involved making up various water and salt concentrations, adding a known amount of London Clay dispersive clay (2-4 mm fraction) and

rolling the r sulting mixture at room temperature and 20 rpm for 16 hours. At the end of this time, the non-dispersed clay fraction (> 0.5 mm) was recovered, dried and weighed.

Shale may be defined as a fine grained sedimentary rock composed of consolidated silt and clay or mud.

Tests on clay samples are equivalent to tests on shales.

Example 1

Salt	Conc. Molar	Conc g/l	% Recovery
NaCl	0.001	0.0585	0.5
	0.01	0.585	0.6
	0.1	5.85	0.5
	0.5	29.25	0.4
KCl	0.001	0.075	0.8
	0.01	0.75	0.8
	0.1	7.5	2.3
	0.5	37.5	7.3
CsCl	0.001	0.170	0.6
	0.01	1.70	8.6
	0.1	17.0	64.4
	0.5	85	81.9

The higher the recovery of clay the higher is the inhibition of clay dispersion. The caesium chloride increases the clay inhibition substantially compared to the potassium chloride.

Example 2

An aqueous drilling fluid was prepared according to the following formulation by low shear mixing.

Seawater	to 1 bbl
Caesium formate monohydrate	25 ppb
Carboxymethyl cellulose	3 ppb
Partially hydrolysed polyacrylamide*	1.0 ppb
Xanthan gum (XC)	1.2 ppb
Potassium hydroxide	to pH 10.0
Barite	83 ppb
Simulated drill solids**	10 ppb
Mud weight specific gravity	1.2

* Molecular weight about 10 million.

** Hymod Prima clay from English China Clays, with a mean particle size of 1.14 micrometres.

The rheological, fluid loss and shale inhibition properties of the fluid were tested.

Rheology

Measurements were made using a Fann Model 35SA viscometer at 20°C. The results were as follows.

rpm	600	300	200	100	6	3
Scale reading	38	27	22	16	5	4

Plastic Viscosity (PV) 11 cP, Yield Point (YP) 16 lbs/100 sq ft and gels (10 s/10 min) of 5/6. The corresponding figures for a comparable 1.2 specific gravity KCl aqueous drilling fluid (Comp A) with the above analysis but caesium formate replaced by an equal weight (25 ppb) of KCl has PV 9 cP, YP 16 lb/100 sq ft and gels (10 s/10 min) of 4/5.

Fluid Loss

The fluid loss with the drilling fluid in the API standard test was 5.8 mls. The test was performed by placing the fluid in a filtration cell which is pressurised to 120 psig with nitrogen gas. A standard Whatman No. 50 filter is used and the total volume of filtrate which exits from the cell after 7½ minutes (V_1) and 30 minutes (V_2) is noted. The corrected fluid loss value is equal to 2 (V_2-V_1) in ml.

The fluid contained 1% of a standard clay (Hymod Prima clay ex ECC). The basic fluid formulation was otherwise as described above.

Dispersion Control

This was tested by the Slake Durability Test (SDT) which uses approximately 100 g of London Clay shale chips in the size range 4-8 mm. The chips are placed inside a cylindrical drum whose curved surface comprises a 0.5 mm brass or steel mesh. The drum containing the shale is partly immersed (to half the diameter of the drum) in the fluid under test and the drum rotated for 4 hours at ambient temperature. After this time the shale is recovered, washed, dried and the amount of shale lost by dispersion into the mud is calculated.

The aqueous drilling fluid of this Example was compared in this test with the corresponding KCl based fluid (Comp. A). The percentage recoveries of the clay shale were 68.1% for the caesium formate fluid and 43% for the KCl fluid, even though the KCl fluid contains about 2.6 times the molar amount of KCl.

Claims:

1. An aqueous drilling fluid comprising.

(a) an aqueous medium,

(b) a caesium salt, e.g. in amount of 0.5-50ppb (pounds per barrel) (0.85-150 g/l),

and at least one of

(c) a fluid loss additive,

(d) An organic water soluble shale dispersion inhibitor, and

(e) a weighting agent.

2. A method for drilling through shale using an aqueous drilling fluid, which comprises drilling using an aqueous fluid comprising a caesium salt.

3. Use of a caesium salt as a shale inhibitor in an aqueous drilling fluid.

Patents Act 1977
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.he Search report)

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(ii) Int Cl (Ed.5) C09K

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Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE WORLD PATENTS INDEX

Documents considered relevant following a search in respect of Claims :-
1 TO 3

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X P	GB 2265924 A	(ICI)	1-3
X P	EP 0572113 A	(B P CHEMICALS)	1-3
X	EP 0137872 A	(HALLIBURTON) - see page 3, line 13 - page 4, line 1 and page 5, line 15 - page 6, line 14	1-3

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).